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International Workshop on Greenhouse Gas Mitigation Technologies and Measures: Summary

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INTRODUCTION

The 1995 IPCC report states that human activities are increasing the atmospheric concentrations of GHGs. Overall, GHG emissions from the industrialized countries constitute a larger share, but those from developing countries are increasing faster because of their higher economic and/or population growth.

National policy makers need information on the magnitude of the GHG reduction potential and the costs and benefits of mitigation options. Country mitigation assessments can form the basis for the preparation of national action plans by identifying and evaluating policies and measures for reducing future GHG emissions. Policy makers can then weigh the costs and benefits, and impacts of climate change mitigation options, in the face of competition for limited government funding. Information in the action plans may then be provided to the FCCC as part of a country's reporting requirements.

The results presented at the International Workshop on Greenhouse Gas Mitigation Technologies and Measures form the basis for each country's national communication or climate action plan. The workshop presentations included national mitigation assessments, and analyses of mitigation options for the energy, forestry, and agriculture sectors. This summary provides an overview of the papers presented at the workshop as well as the results of five sector-specific group discussions on renewable energy, energy efficiency in industry and buildings, electricity supply, transportation, forestry, and methane mitigation.

NATIONAL MITIGATION ASSESSMENTS, TECHNOLOGY PRIORITIES, AND MEASURES

Representatives from China, Indonesia, Slovak Republic, Hungary, Ukraine, Venezuela, and Tanzania reported the results of their national GHG mitigation assessments. A comparative analysis of mitigation strategies of nine Central and Eastern European countries was also presented.

Wu Zongxin presented China's energy-related CO_2 emission projections up to the year 2030 and potential GHG mitigation options. China's study analyzed technology options, focusing on energy conservation and energy substitution measures, in terms of their mitigation potential, local pollutant reduction potential, local eco-system impacts, technology availability, and economic and social benefits. It showed that energy efficiency improvement offers China a "no regret" option for CO_2 reduction.

Mitigation measures for China's energy sector include: 1) cleaner and more efficient use of coal; 2) establishment of a national and regional natural gas pipeline network; 3) modernizing biomass energy use, 4) adoption of integrated resource planning; 5) demonstration projects and subsidies to promote advanced technologies; 6) energy pricing and taxes to promote efficient energy use; 7) development of end-use performance standards; and 8) increasing use of demand side management. Renewable energy (biogas, solar, wind) is a also promising mitiga-

tion option for China. Two thirds of China's population live in rural areas, and renewables could provide energy to improve their living standards and promote rural economic development. However, while energy efficiency improvement is a "no regret" option for CO_2 reduction, developing renewable energy involves incremental costs.

Mitigation options for reducing CO_2 emissions from Indonesia's energy sector were presented by RTM Sutamihardja. Indonesia's mitigation scenario aims to reduce GHG emissions from the business as usual (BAU) scenario by 10% in the year 2010 and 20% in the year 2020. This is expected to change the final energy mix—reducing demand for coal by 8% by 2005 and 30% by 2020, as compared to the BAU scenario.

Mitigation measures for Indonesia's residential sector address lighting, refrigeration and air conditioning. In the industrial sector, the use of variable speed motors and cogeneration are identified as GHG mitigation options. In the power sector, advanced power plant technology, such as integrated coal gasification combined cycle, pressurized coal fluidized bed combustion, and fuel cells are potential mitigation options. While Indonesia has large natural gas reserves, resources are located far from the demand sources. This presents a geographical constraint on the feasibility of natural gas use as a mitigation option.

Nikolai Raptsoun presented results from the GHG mitigation assessment for Ukraine. Ukraine's GHG emissions forecast and mitigation options have been affected by the uncertainties presented by its current transitional state, and therefore three macroeconomic scenarios were developed to reflect low, medium and high economic growth.

Adoption of energy efficient technologies was found to be the most important measure for reducing GHG emissions in Ukraine. Specific measures include cross-sectoral energy saving options, such as efficient lighting and improving heat supply systems, as well as sector-specific efficiency improvements in the power, agricultural, transportation, and residential sectors. Fuel substitution, reduction of losses in the gas supply system, and improved industrial processes are also important.

In Ukraine's forestry sector, mitigation measures include forest protection and conservation, improved forest management and harvesting, reforestation, and agroforestry. Implementation of such measures could increase CO_2 uptake by approximately 15g in 2015, at an estimated cost of US$1.2 billion.

Sandor Molnar presented four ongoing governmental programs that form the base of Hungary's national mitigation plan. These programs address energy efficiency and conservation, afforestation, reduction of volatile organic compound (VOC) emissions, and reduction of ozone depleting substances (ODS). They were launched in the beginning of the '90's but have been slowed due to national budgetary constraints.

In their mitigation assessment, the Hungarian team focused on the power sector and district heating. Promising mitigation measures planned for near future include: fuel switching; retiring old, inefficient power plants, constructing fluid bed units and combined cycle gas turbines, constructing a new nuclear power plant, and increasing the share of cogeneration in the electricity and heat supply.

Molnar explained that the majority of forests in Hungary are sustainably managed but the current Afforestation Program has fallen way below its targeted afforestation rate. Because of this and poor economic conditions, the baseline scenario assumes no afforestation. Four mitigation scenarios based on afforestation were presented. The " likely-trend" scenario estimates afforestation of 3,000 ha annually, reflecting afforestation rates since 1990. Scenario two calls for afforestation of 150,000 ha in the next decade, scenario three calls for afforestation of 600,000 ha by 2050, and the fourth scenario call for nearly one million ha of land to be reforested by 2050.

Martha Perdomo presented results of the Venezuelan mitigation assessment. The study found the most effective options in the energy sector to be transportation measures, both in terms of emissions reductions and cost, which was negative for all transportation options. The three transportation options analyzed were: 1) switching to more large capacity vehicles; 2) maintaining current share of private vehicles; and 3) switching to natural gas vehicles in the city bus system.

The adoption of sustainable forestry practices also shows considerable potential for reducing CO_2 emissions. Since deforestation is a serious problem in Venezuela, maintenance of existing biomass in natural forests, through forest protection and management, should be of highest priority.

Despite these opportunities, Perdomo cited several barriers to implementing mitigation measures in Venezuela. Among them are: low energy prices; lack of institutional capacity, legal instruments, and land tenure laws; rural poverty; and weak environmental laws.

Mark Mwandosya presented the results of Tanzania's mitigation assessment. He explained that mitigation options for each sector were assessed by weighing them against a number of criteria, including sustainability and significance of the options, second order effects and social acceptability of the technologies.

The assessment ranked options by order of priority. The five measures of highest priority were: 1) repowering; 2) upgrading thermal power plants to combined cycle plants; 3) increased efficiency in industry; 4) grassland management; and 5) improved charcoal kilns.

Lastly, Katja Simeonova of Bulgaria presented an analysis of the National Communications of nine Central and Eastern European Countries that are currently in economic transition. She found that, due to the economic transition, most mitigation policies and measures implemented were cost effective "no-regret" measures. They primarily addressed CO_2 from fossil fuel combustion as the most important GHG, and the energy transformation sector as the major

source of GHG emissions. Increased efficiency through new technologies, increasing the share of renewables and natural gas, promoting energy efficiency, improving management practices, maintaining the share of nuclear energy and upgrading centralized heat supply systems were some of the policies considered most frequently for the energy sector. Increasing energy efficiency in end use sectors was also identified as having high potential for energy savings and GHG mitigation.

In the non-energy sector, Simeonova reported that enhancing carbon sink capacity was determined to be an important mitigation measure for many countries. Several transition countries included improving forest management practices and afforestation in their national communications.

SECTORAL MITIGATION ASSESSMENTS, TECHNOLOGY PRIORITIES AND MEASURES

On the second day of the workshop, results of sectoral mitigation assessments were presented. Energy sector reports were given by Russia, Bulgaria, Czech Republic, Kazakstan, Thailand, Egypt, Philippines, Bangladesh, and Hungary. Reports on mitigation measures for the non-energy sectors were presented by Russia, Slovakia, China, Kazakstan, Philippines and Sri Lanka.

Energy Sector Assessments

A.F. Yakovlev presented CO_2 emission scenarios for Russia's energy sector for 2000 and 2010. In the baseline scenario, CO_2 emissions are 75 - 78% of the 1990 level in 2000, growing to 81-88% by 2010. One mitigation scenario considered probable investments in energy efficiency improvements, and estimated that CO_2 emissions would be reduced by 6% from the baseline scenario in 2000 and 25% from the baseline by 2010. The "optimistic" scenario, which included enhanced investment in energy efficiency improvements, estimated reductions of 16% for 2000 and 31% for 2010.

Yakovlev pointed out that in Russia mitigation measures in the energy sector are directly connected to the National Energy Strategy, much of which was approved in 1994. Key measures include: 1) increased share of natural gas consumption, 2) expansion of renewable energy use 3) more efficient conversion of fossil fuels, 4) upgrading power plants with economically and ecologically sound equipment; and 5) increase in the safety of nuclear power plants. Institutional and legislative measures will be implemented to further develop energy markets and support the measures listed above.

P. Tzvetanov presented macroeconomic and final energy demand scenarios for Bulgaria, including a detailed assessment of the energy efficiency potential. Under the energy efficiency scenario, the study found that final energy demand in the production, transport, and household and service sectors will decrease up to the year 2005, but after that will increase, primarily due to growth in the transport sector. The area with the biggest potential for energy savings is the production sector, followed by transport, and then household and services. While the

energy efficiency scenario would slow economic growth initially, it would lead to accelerated growth by the end of the study period (2025), surpassing estimated growth in the baseline scenario.
Tzvetanov explained that the viability of the energy efficiency scenario depends on a number of regulatory aspects. The most important of these are: 1) passage of the Bulgarian Energy Efficiency Law, which would establish conditions for a unified energy efficiency policy for both energy production and consumption; 2) use of Integrated Resource Planning; and 3) motivating energy supply companies to increase energy efficiency, particularly to implement demand-side management.

Christo Christov followed Tzvetanov's presentation with an assessment of mitigation options for Bulgaria's energy sector, including both energy demand and supply measures for the period 1992-2020. Some of the mitigation options he mentioned were: upgrading existing heating and cogeneration plants with natural gas combined cycle units, increased use of renewable energy, and reduction of energy losses. The study concluded that energy demand mitigation measures are more effective than supply side measures in reducing GHG emissions in the medium term, because of current transition from an energy intensive economy. In the long run however, the potential for structural changes and energy efficiency improvements would be exhausted and energy supply mitigation measures become more effective. However, he showed that mitigation options addressing only either supply or demand were not sufficient to stabilize emissions, and that a proper mix of measures in both areas was needed to gain significant emissions reductions.

Milos Tichy of the Czech Republic reported that his country would have no difficulty fulfilling the FCCC obligation (that GHG emissions not exceed 1990 levels in the year 2000), if the GDP grows within the expected range of 3.2 - 4.7%. Emissions growth has been delayed due to new limits on regional pollutants now taking effect in the Czech Republic and replacement of coal with gas nuclear energy. However, CO_2 emissions are eventually expected to increase. The Czech analysis of mitigation options emphasized energy demand options as the most effective measure for reducing GHG emissions.

The Czech assessment proposed several policies for inclusion in the Czech Climate Change Action Plan. These included legislative and standardizing policies (i.e. introducing energy labels and appliance standards), tax policies (i.e. carbon and energy consumption taxes), subsidization policies, and negotiations with equipment producers and buyers (i.e. voluntary agreements and facilitating leasing of energy efficient technologies).

Results of the Czech mitigation assessment show that end use consumption can by reduced by 7-8% in 2010, in comparison to the baseline scenario. This is equivalent to about 9Mt of CO_2 /year. The largest savings in absolute terms were in the area of process heat in industry, which accounted for almost one third of the total savings.

Ivan Mojik presented Slovakia's mitigation assessment for the energy sector. He introduced three possible scenarios. The baseline scenario assumes compliance with the Slovak Republic Air Protection Act, which, although aimed at reducing local pollutants, includes many GHG reducing measures. The "pessimistic" scenario expects poor or no implementation of emission limits. The third scenario includes mitigation measures beyond the current legislation. The most effective measures were found to be 1) increasing boiler efficiency, 2) fuel switching, 3) deregulation of heat prices while maintaining fuel and electricity price regulations, 4) maintaining the level of electricity production from nuclear power plants, and 5) use of continuous casting and combined cycle cogeneration at the largest iron and steel enterprise. While these options are expected to form the base of the Slovak mitigation plan, he pointed out that even achieving the baseline scenario would not be likely, due in large part to Slovakia's current social and economic situation.

Svetlana Mizina presented an assessment of GHG mitigation measures and technologies for Kazakstan's energy sector, with an emphasis on energy production. A baseline scenario and six mitigation scenarios were developed to evaluate the most attractive mitigation options, focusing on specific technologies which have been proposed in energy programs. According to the study, the most promising options, in terms of mitigation potential and technical and economic feasibility, include (in order of priority): rehabilitation of thermal power plants to increase efficiency, installation of small hydroelectric plants, use of nuclear power, installation of wind power plants, and the use of solar energy. Mizina reported that under the baseline scenario, Kazakstan would not exceed 1990 emission levels until after 2005. Assuming the mitigation options, the maximum reduction in CO_2 emissions would be about 11% of the base line by 2020.

Prapat Wangskarn reported on the results of work being done under Thailand's Energy Conservation Program (ENCON) to estimate energy intensity and CO_2 emission reduction potential in the country's manufacturing sector. The study, which was based on energy audits of fourteen factories, included assessing energy consumption, identifying existing and candidate technologies to improve energy efficiency and reduce GHG emissions, and identifying individual factories for further study.

Two Thai energy and CO_2 emission reduction scenarios were devised. The "moderate" scenario consisted of measures that had a payback time of less than four years. The "intensive" scenario included measures that had a longer payback period but were still cost-effective. The moderate scenario produced energy savings and CO_2 reductions of 7% while the intensive scenario yielded additional energy savings of 3% and additional CO_2 reductions of 5%. Although significantly higher savings can be achieved if longer payback periods are accepted, manufacturers are often reluctant to invest in such projects. Overcoming this reluctance could be an important goal for ENCON.

Salah El-Touny presented mitigation options for Egypt's industrial sector, focusing on three energy efficiency projects currently underway. The first project assesses GHG mitigation options for Egypt's oil refineries. The results showed

that improving combustion efficiency of boilers is the most effective measure, financially and in terms of mitigation potential. El-Touny described two projects currently underway in Alexandria. The first analyzes the energy-efficiency opportunities in small and medium enterprises. The other project is a demand side management (DSM) pilot project designed to provide training and information on DSM, evaluate its effects on GHG emissions, and promote it to electric distribution companies in Egypt.

The Philippine mitigation study, presented by Clovis Tupas, found that the best mitigation options in the energy sector, in terms of financial attractiveness and CO_2 mitigation potential, were energy-efficient technologies (compact fluorescent lights, high efficiency air conditioners, and improved ballasts) and fuel switching (hydro and natural gas). Some measures, such as DSM measures for residential consumers, while attractive financially, have less impact in terms of emissions reductions as compared to energy efficiency measures in industry or in power production and transmission.

Bangladesh has received attention as a country that would suffer greatly from global climate change. M. Asaduzzaman explained that while Bangladesh is in need of an appropriate adaptation strategy, and emits a very small amount of GHG, a mitigation strategy is necessary because of the country's growth prospects, its dependence on imports for its fossil fuel-based energy supply, and its limited supply of natural gas. He reviewed Bangladesh's current energy consumption and potential areas for savings. Lowering energy intensity through increased efficiency should be the core mitigation measure. Improvements in the power sector are important in this regard, not just because of inefficiencies, but also because demand for power is expected to increase rapidly. The industrial, transportation and residential sectors were also identified as areas for efficiency improvements. He noted that technology and cost would prove important in selecting mitigation options, and that AIJ needs to be seriously considered

Non-Energy Sectors Assessments

Alexey Kokorin presented various scenarios for the future of Russia's forests and identified regional forestry priorities for the Russian Climate Change Action Plan. The scenarios, one baseline and four others, considered the effects of clear-cut logging, reforestation, selective logging and thinning, and measures to prevent and manage fires. Only the scenario incorporating forest fire control measures increased the carbon net-sink by 2040. Mitigation measures were proposed for each region. For the European-Ural region he suggested the creation of an economic mechanism to increase logging efficiency and assistance for natural reforestation. For South Siberia and Primorie and Priamurie, options included limiting clear-cut logging and establishing a market system to increase forestry efficiency. The Vologda AIJ reforestation project being considered by the US and Russian governments was in agreement with these priorities.

Measures to reduce nitrous oxide (N_2O) and methane (CH_4) emissions from agriculture and waste treatment in Slovakia were presented by Katarina Mareckova. She reviewed some measures that are already being implemented in Slovakia

(though not motivated by climate change) and other proposed mitigation options. In addition to the baseline scenario, three mitigation scenarios were presented—low, medium, and high. The medium scenario estimated a reduction of CH_4 emissions of approximately 20% of the 1990 level by 2005, and a reduction of N_2O emissions of about 25% in the same time period.

Hashem Akbari's research focused on urban trees and light-colored surfaces as climate change mitigation options. He explained that trees that shade buildings reduce air conditioning use and improve comfort, while trees in city neighborhoods lower ambient temperature by evapotranspiration. Light colored roofs reduce the need for air conditioning by reflecting the incident solar radiation and light colored surfaces in neighborhoods lower ambient temperatures by altering the surface energy balance. Lower ambient temperatures reduce air conditioning use and smog formation.

Akbari calculated the potential energy savings and smog reduction in Los Angeles, California. His study assumed that eleven million trees would be planted and all of the 2,500km^2 of roofs and pavement in Los Angeles are modified. The result was a potential savings of US$0.5 billion/year by 2015, through a combination of direct and indirect energy savings and smog savings.

Lin Erda reported on GHG mitigation options for the agriculture sector in China. He explained that options are available that could significantly reduce CH_4 and N_2O emissions, with the additional benefit of increasing crop and animal productivity. CH_4 emissions could be reduced from rice, ruminants and animal waste by 4-40%. Improving the efficiency of plant utilization of fertilizer N could reduce N_2O emissions from agriculture by almost 20%.

Lin presented a plan for Chinese rural biogas development which includes building biogas generators on 200 intensive livestock farms, and increasing the number of families using biogas to 7.55 million by 2000. Biogas production would reach 2.26 billion m^3, substituting for 1.7 million tons standard coal. CH_4 recovery would be 1.2-1.6 billion m^3.

Svetlana Mizina presented mitigation options for Kazakstan's non-energy sectors. Measures in land-use change, forestry, agriculture and coal mining were considered. Coalbed methane utilization was found to have great GHG mitigation potential. In 1990 coal mines accounted for about 49% of Kazakstan's total methane emissions. There are a number of well developed technologies and pilot projects which could capture the methane currently being emitted into the atmosphere for productive uses.

Leandro Buendia presented a summary of work done in several Asian countries on CH_4 emissions from rice ecosystems. The goal of the study was to develop sampling strategies and formulate mitigation options based on daily and seasonal patterns of methane emissions. Mitigation strategies were grouped into two categories—preventative or reducing. Preventative measures consider, prior to planting, the ecology and fertilizer management that will result in less methane emission. Reducing measures are necessary when preventative measures are not

feasible. The study has resulted in a better understanding of how and when mitigation strategies can best be applied.

S.Y. Namaratne presented an evaluation of CH_4 emissions from three rice cultivars in Sri Lanka. The study found no statistically significant difference with respect to methane emissions from the three varieties. He concluded that further studies on other popular rice varieties are needed to identify cultivars that generate low methane fluxes.

IMPLEMENTATION OF MITIGATION TECHNOLOGIES AND PRACTICES

During the second and third days of the workshop, participants attended sector-specific working groups on the implementation of mitigation technologies and practices. The sectors covered were: renewable energy, energy efficiency in industry and buildings, electricity supply, transportation, forestry, and methane mitigation. Each session included several presentations and a discussion period focused on technology priorities, barriers to technology adoption; and policies; and programs and projects to promote technology adoption. Following is a summary of each session, as reported by the chairpeople and rapporteurs who led each group.

Renewable energy

Renewable energy technologies can play a significant role in reducing the growth of GHG emissions in many types of economies. A forum was conducted during the workshop to provide information and a dialogue on how these technologies can enter into a country's energy production system. The objectives of this session were: to discuss the implementation of renewable energy mitigation options, to identify key project development steps, and to develop recommendations on project development issues and technical assistance needs.

Using results from the recent IPCC report, Matthew Mendis described how the use of fossil fuels to generate electricity contributes to the climate change phenomenon. As we move into the 21st Century, renewable energy technologies can play a substantive role in reducing GHG emissions associated with the electric power sector around the world, particularly where developing countries are struggling to meet rapid growth in demands for new energy supply. He noted that a complete rethinking of the electric power industry might take place over the next few decades to address climate change issues, and that renewables will play a major role in this.

Implementing Renewable Energy Projects. Jim Ohi explained that project development begins with identifying the target region or service area, along with who the energy service providers will be, and decisions on whether grid connected or off-grid renewable technologies will be used. The next step is to conduct a socio-economic evaluation of the region, including income level, economic activity, energy use, energy service needs, and willingness to pay for new energy services. An assessment of the renewable energy resources, including site specific data and acknowledging the role that resource uncertainty can play in project investment,

is also a step in this phase of the planning process. Furthermore, an evaluation of the technologies that can match the energy service needs, given cost and performance considerations, is required. At this stage, prefeasibility studies, which include technical, economic, and institutional evaluations, and subsequently, feasibility studies, which address sustainability requirements, potential for economic and social development, project financing, implementation, and carbon offset issues, are conducted. This then leads to an investment decision involving the public and private sectors, which takes into account projected risks and financial returns, so that the most suitable institutional structure can be determined.

David Renné discussed the importance of assessing renewable energy resources in order to capture the true potential of renewable energy supply in a country or region. He also described the importance of reducing uncertainties in the assessment of resources at proposed sites in order to improve the confidence in investment in projects. He described some recent methodologies that have been developed that are used to provide large scale assessments of solar and wind resources in the absence of adequate surface data collection programs.

Renewable Energy Development in China. Li Junfeng summarized the renewable energy activities and initiatives that are taking place in China to help meet its rapidly-growing energy demands. Grid-connected wind energy is expected to see major growth over the next few decades. The Ninth Five-Year plan has established goals of 1000 MW installed by the year 2000, and 3000 MW by the year 2010. The use of solar photovoltaic home systems to meet rural electricity demands is also a major program. Currently about 6 MW of solar home systems are installed in China, primarily in the western provinces, with about 1 MW/year being added. Another important technology is biomass gasification for home use. There is a potential of 1000 MW of large-scale biogas power generation projects using animal, urban, and industrial wastes. Other programs include the 100 Counties program for rural energy planning and development, and a program to install 100 micro-hydro systems (totaling 1500 MW of power). China is also pursuing several policy initiatives to encourage the development of renewable energy.

Shi Pengfei described China's wind energy activities in further detail. Based on national resource assessments, the total potential wind energy supply for China is estimated at 257 GW, not taking into account terrain features. Currently, 36 MW of grid-connected wind energy are installed at the top five wind sites in China. To achieve the goals of the Ninth Five-Year Plan, a detailed assessment of wind resources in China is needed in order to meet a market potential of 400 to 1000 MW by the year 2000. In addition, incentives are needed from the central government to achieve these goals. At this time, large wind turbine generating systems have to be imported; international cooperation in helping China establish an indigenous manufacturing capability will be required.

Rural Electrification. Jerome Weingart described the evaluation and implementation of hybrid renewable energy systems to provide off-grid power to villages. He showed how hybrids (such as wind/solar systems with battery and even diesel back-up) can be quickly installed to provide reliable power to villages, often

at considerably less cost than by extending the electric utility grid to the village. He noted how this can be an important contributor to mitigation of GHGs, since nearly 40% of the world's population currently lives in areas that are not connected by electric utilities.

Neville Williams gave an inspiring talk about bringing "wireless electricity" to rural homes through projects in which he is involved in China, India, and Vietnam. Vietnam, for example, is a country where nearly 75% of the population lives off the grid. Solar home systems not only improve the quality of life of the inhabitants by removing their dependency on kerosene lamps and providing improved lighting and electricity for household appliances, they serve to offset over 6 ton/C by displacing kerosene lamps over their lifetime.

Participants debated the effectiveness of rural electrification policies to stimulate the use of renewables as opposed to extending the electrical grid or purchasing diesel generator sets. Rural electricity has generally been subsidized by local governments throughout the world, and policies should be established to encourage the use of renewables in providing rural electricity in developing nations.
Conclusions. There was a strong consensus in the group that renewable energy technologies can play a prominent role in reducing GHG emissions, improving air quality, and providing rural electrification for millions of people as we move into the 21st Century. There is likely to be a significant revolution in the way utilities provide electricity to people, and renewable energy technologies can play a strong role in future energy supply scenarios.

Energy efficiency in industry and buildings

Four papers were presented in the session on Energy Efficiency in Industry and Buildings. Following is a brief summary of each of the presentations, and the key points of the discussion.

The GEF High Efficiency Boiler Program in China. Tan Meijian of the GEF Efficient Industrial Boiler Project Office reported on the High Efficiency Boiler Program in China, an eighteen year effort that started 1992 and whose goal is to introduce more energy efficient steam boilers in China. The paper presented details of a strategy to introduce new coal fired boiler designs, adapt the technology to local conditions, manufacture the new design in China and also improve operating techniques to increase the overall thermal system efficiency from 65% to 80%.

Some participants raised the issue that more modern and efficient boiler designs will be more expensive (particularly if automatic oxygen trims and other features such as economizers and air preheaters are incorporated) and that is not clear to what extent the market will be willing to pay for increased energy efficiency, which may double the present cost of a boiler. As a solution, Tan Meijian said that efficient boilers could be made mandatory.

Another concern was that modern, highly energy efficient boilers require better quality coal for firing. Traditionally, there has been competition between steaming coal and coking coal, with all bad quality coal usually sold as steaming coal.

One serious barrier to introducing highly energy efficient boilers may be a shortage of better quality steaming coal or premiums paid for such coal.

Efficient Lighting Programs. Liu Hong discussed efforts in China to introduce efficient lighting programs, primarily in the residential sector. In response to his presentation, several issues were mentioned by participants, including :

1) The advisability of copying foreign efficient lighting programs that have resulted in an additional financial burden to Government owned utilities. In particular the recommendation to subsidize efficient lights was questioned.
2) The extent to which subsidies will really speed up market penetration of efficient lights and how sustainability can be achieved if lights are subsidized the first time and the user is asked to pay the full price upon repurchasing.
3) The quality of locally manufactured efficient lights. It was suggested that the quality of these lights may be acceptable, but that the poor quality of local power may lead to a shorter than expected technical life of lamps.

Ming Yang of the IIEC discussed some documented success stories in promoting efficient lighting and energy management in buildings in various Asian countries. One interesting strategy used in Thailand to reduce sales of inefficient lighting involved retailers of 20 and 40 Watt FL-lamps agreeing to phase out sales of such lamps in favor of offering only 18 and 36 Watt lamps.

The main concern voiced by the participants was the credibility of claims of energy and cost savings. Analysts need to clearly distinguish between saving potential and verified savings.

Energy Efficiency Marketing in China. Feng Yan presented a broad spectrum of possible models for energy service company (ESCO) services and client-ESCO relations to improve energy efficiency. He explained that foreign ESCOs could enter the Chinese market, according to official statements by the Chinese government. Based on experiences in other countries, group participants argued that it is unlikely that local ESCOs alone could handle a broad field of technological challenges encountered in improving energy efficiency in industry. Often, very specialized knowledge is needed that would require foreign input.

The strategy to base ESCO services on performance contracting was briefly discussed and it was pointed out that the difficulty lies in the costs and time spent to verify energy savings, making performance contracting a high risk venture that only the most experienced ESCOs could afford.

Electricity supply

This session encompassed three papers, two of which focused on electricity production and one on transmission and distribution practices. The papers provided examples of power supply efficiency from turbine blade retrofitting and power plant operations to power factor balancing in distribution systems.

Albrecht Kaupp made an interesting comparison between DSM and supply side management (SSM), and their respective effects on consumer and supplier (utility) revenues and operational costs. It was demonstrated that, while both options can be used to mitigate GHG emissions, SSM would effectively reduce utility operational costs while DSM would reduce utility revenues and simultaneously require active consumer participation. As a result, SSM options would be easier to implement especially since they are more centralized and involve fewer players.

The session also discussed a number of key barriers to implementing more supply side energy efficiency. Specifically mentioned were pricing, policy, institutional and regulatory barriers.

Dariush Hourfar, from the German utility VEBA Kraftwerke Ruhr AG, discussed options for reducing CO_2 emissions from power stations. He outlined several ways in which hard coal-fired power plant efficiency can be approved, including: improving steam generator efficiency by reducing exhaust losses, improving turbine efficiency, refurbishing pumps and blowers and; optimizing the cold end. While the mean efficiency of hard-coal fired plants is 36%, new state of the art plants are operating at 43%. He also noted that due to combined heat and power generation, district heating has become one of the most important primary energy saving and environmentally acceptable heating systems, and should be given priority in the future.

The issue of retrofitting older plants versus constructing new plants (with higher thermal efficiencies) was raised. Specifically, it was demonstrated that decisions presently are made strictly on financial criteria without concern for GHG emissions.

Masaru Hirata, from Shibaura Institute of Technology in Japan, provided a brief survey of cogeneration and "repowering" technologies based on high temperature gas turbines fueled by natural gas, which he argues are the most promising option for electricity generation in Northeast Asia, in terms of reducing CO_2 emissions. He also mentioned the Trans-Asian Natural Gas Pipeline which, in addition to tapping the region's vast natural gas reserves, will heighten intra-regional dependence and cooperation.

The main conclusion of the session was that while electricity supply is a major source of GHGs, there are a number of options that could significantly reduce GHG emissions from this sector. However, very little is being done presently to tap this potential in developing countries.

Transportation

Overview of Transportation Issues. John Ernst began the session by presenting an overview of transportation issues and measures. He explained that while transportation accounts for 25% of energy use and 22% of CO_2 emissions globally, few significant mitigation strategies developed to date include measures for

transport. This is because transportation is a complex and difficult policy area, interconnected with multiple policy concerns and social goals.

He presented several factors that underlay the increase in energy use in the transportation sector, including the fact that there are a number of costs associated with road use that are not paid by the users, but instead by governments or society in general. These include:

- infrastructure expenses, such as road building, traffic management, police, and institutions
- direct emissions which have health and environmental effects
- environmental and other social costs of oil exploration and transport
- suburban sprawl, which can result in greater transport energy needs by reducing the effectiveness of modes other than personal vehicles
- congestion and lost economic productivity
- accidents, injuries and deaths

Ernst argued that if full costs and long run societal interests are considered, there are many "win win" opportunities for shifting the pattern of transportation development, particularly in rapidly developing and urbanizing countries. Some strategies can be seen in action in places like Singapore, Curitiba, and Amsterdam. These strategies can: reduce GHG emissions, improve urban form and strengthen communities, reduce dependence on oil imports, increase economic competitiveness, reduce congestion, increase productivity, improve health and reduce other hidden costs now born by governments or citizens generally. The key need now is to focus much more attention on identification, analysis, and implementation of such opportunities before they are lost.

In discussion, participants added several other important points. First, in addition to economists' focus on "internalizing externalities" or hidden costs, it is also important to understand the political cost and benefits of various government roles. These can help explain why it is so difficult to implement some apparently "win–win" options, and highlights the need to build broad societal consensus around an alternative transportation strategy, not just treat it as a technical problem. It may be that technical options are the least important part of the problem, with development of political will being the key. Careful review of the history and development of the existing urban areas can help to illustrate lessons from experience and illuminating alternative models for long term development.

Transportation and Pollution Control Measures in China. Yuan Dongxin summarized a series of successful transportation and pollution control measures being implemented in Xiamen, a small port city in SE China. Since Xiamen was designated a special economic zone in 1980, it has experienced explosive economic growth—21%/year—and even more explosive growth in the numbers of vehicles—41%/year. In response to this rapid growth, the city has taken a strong stand that its environment must be maintained or improved, and has taken serious measures to meet this goal.

The city has adopted a long range, comprehensive approach to transportation planning. It is developing and implementing a number of interrelated measures

which are intended to produce a sustainable transportation system in conjunction with rapid economic growth. These measures include:

- ongoing incentives and education to encourage public transportation
- careful and continuous air quality monitoring
- annual testing of vehicles with mandatory repairs if standards are not met
- programs to eliminate aged, high–emission vehicles
- prohibition of tractors and heavy trucks from the city center, and all vehicles from some areas
- selective improvements to road capacity, bridges, tunnels, etc. to improve traffic flow
- further development of public transportation
- pedestrian overpasses
- plans to introduce electric buses
- use of existing railway for local traffic.

As a result of these measures, Xiamen has been able to increase economic output more than four–fold over the last fifteen years, while improving environmental conditions. In discussion, it was clear that this is a striking example of the type of alternative transportation approach for which many analysts are searching. It demonstrates how significantly planning and policy measures can alter the transport development of a city if enlightened leadership and political will can be brought to bear.

Chen Zongmin presented a summary of China's commitment to compressed natural gas (CNG) vehicles. Significant investments have already been made in research and development, and in demonstration projects in several regions. By 1995 over 40 CNG refueling stations were in operation, servicing over 3000 vehicles. Preliminary plans call for construction of 33 more stations and conversion of 4000 vehicles in the near future. Also in this period, facilities will be established to produce compressors and conversion equipment, and to service vehicles. China appears well on the way to developing a substantial CNG vehicle industry that will have economic as well as local and global environmental benefits.

Ming Yang presented an analysis of the potential role and rationale for CNG buses in Beijing. This study evaluated several alternative fuels including electric cars and determined that CNG was the best option for Beijing. The analysis, based on today's costs for fueling stations and vehicles, shows a payback of 4–5 years. A number of barriers have been identified which must be overcome, largely through government programs initially.

Transportation Measures in Venezuela. Martha Perdomo touched on a wide range of transportation measures being implemented or considered in Venezuela. These include gasoline price increases, rail construction, new bus and subway service and some road improvements—all expected to reduce GHG emissions and improve the local economy and environment. The focus of the paper was on CNG buses. By 1995, 4000 vehicles were operating, with 3000 more expected by the end of 1997. This effort is expected to achieve significant GHG emissions reductions over time.

A discussion at the end of the three CNG–related papers brought out that initial finance costs in both China and Venezuela were, to a significant degree, provided by government. In both cases government support was based on clear societal benefits, both economic and environmental. It seems likely that these industries can become commercially self–sustaining over the long term.

Forestry

In this session, afforestation and other GHG mitigation options in the forest sector were considered. An overview of mitigation policies and measures in the forestry sector was presented by Dr. Jayant Sathaye of LBNL. His report initiated a discussion that focused on the following topics.

The group discussed the integration of forestry mitigation measures in activities of other sectors. Forestry measures can be very effective and inexpensive. However, in the majority of countries, forestry problems should be evaluated in light of their agricultural, environmental and other social and economic impacts. In developing and transition economy countries forestry measures should be developed as a part of a national development strategy. On the other hand, secondary climate change mitigation effects can and have to be identified and promoted.

Forestry mitigation measures usually deal with afforestation, reforestation or forest protection. However, other forestry measures can be more cost-effective. For example, reduced impact logging, including selective logging, technologies of logging and in-forest transportation, and assistance to natural reforestation after logging, are very promising options. The creation of an economic mechanism (and new legislation) is important to the implementation of such practices.

Improved wood-product use is a mitigation option that links together forestry, construction, fuelwood consumption and other activities. The IPCC has prepared a methodology for including carbon implications of wood product use for the next version of its Inventory Guidelines. However, this module is not yet being used and the effects of improved wood-product use are not currently included in inventory calculations (this means that such measures are outside of the obligations of the FCCC Annex 1 countries). This is an important problem for the majority of transition economy countries.

While monitoring and verification of mitigation measures do not present major problems in the forestry sector, uncertainty in calculations and estimates is an issue. Sometimes new forest inventory results are primarily a correction of old inventory calculations rather than a reflection of new activity. Sustainable forestry practices are usually mentioned as a goal for the future. However, sustainable forestry criteria and certification standards are not accepted universally. The group agreed that such standards and criteria should be investigated and expanded as soon as possible.

Financial problems were mentioned many times during the group discussion, specifically with regard to present and future sources of financial resources for miti-

gation measures. Participation in Joint Implementation activities, other kinds of international cooperation, and support from international funds were considered promising sources. Therefore, the development of the FCCC process, relevant technology transfer and international cooperation are of key importance.

Methane mitigation

Overview of Group Presentations. The session on methane mitigation involved a brief discussion of the various methane mitigation options and issues associated with these options, but focused primarily on three different programs in various stages of implementation. The first presentation summarized the efforts to date in China to capture and utilize coalbed methane, primarily focusing on how the country was trying to find solutions to the technical barriers that had been identified. The second presentation discussed landfill methane mitigation in China as part of the Global Environment Facility's (GEF) recently approved project. The third presentation discussed some recent field work that has been done in the Philippines by the International Rice Research Institute to understand the impact of different rice field methane mitigation strategies (including the introduction of new cultivars and alternative watering practices). This is one of the first studies to actually measure the impact of these various mitigation options.

Participants remarked that they have had a difficult time obtaining accurate records or information on the level of aggregate emissions from methane sources, particularly from rice fields, livestock manure, ruminant livestock, solid waste management sites, and wastewater treatment sites. The IPCC methodologies tend to overstate methane emissions, and most countries have not used more refined methods to estimate aggregate emissions or to estimate emissions at specific sites. One reason for this is the difficulty countries are having even locating individual methane sources (i.e., a particular dump site, farm, or rice field). The exception is China's coalbed methane sector, which has estimated emissions from specific mines as a prelude to project development.

The group agreed that engaging the private sector was the preferred approach to methane mitigation. Limited government involvement via publication of relevant data and methane mitigation project facilitation was the next most popular approach. These preferences came largely as a result of participants' hearing of the success of the China and U.S. cooperation on coalbed methane development. None of the participants thought that regulation or tax incentives could feasibly be enacted.

Participants also agreed that learning how to structure economically successful projects was an important step for countries planning to implement methane mitigation projects. This would involve learning how to perform detailed economic assessments of individual methane mitigation projects; drafting project proposals that are attractive to private sector financiers, multilateral and bilateral development agencies; and understanding which attributes make projects attractive to these entities. These activities were felt to be the most important things that policy makers could do to help the development of methane mitigation projects in their countries.

Participants stressed the need for understanding the differences among mitigation options, including their differing levels of success in methane mitigation, economic performance, and acceptability by the stakeholders. This was particularly felt to be important in the area of rice field methane mitigation, as the mitigation options there are only now being understood.

Finally, participants stressed the need for a system to track emissions reductions from projects after they are implemented, to understand how successful methane mitigation efforts have been. This was felt to be easy for coalbed methane, landfill methane, and livestock manure methane mitigation projects, but harder for rice field methane and ruminant methane projects.

SUPPORT FOR MITIGATION TECHNOLOGIES AND MEASURES

On the last day of the workshop, participants heard presentations on programs supporting implementation of mitigation technologies and measures. Mukul Sanwal gave an overview of National Communications reporting requirements and financial assistance for Non-Annex 1 Parties. Representatives of the U.S. Country Studies Program, the German Bi-Lateral Development Cooperation and the Global Environment Facility (GEF) described the type of work done by their programs and their experiences to date. This was followed by presentations on joint implementation (JI) programs and concepts, also called activities implemented jointly (AIJ), by representatives of the United States, the Netherlands, and the International Energy Agency.

Program Overviews

Mukul Sanwal summarized the guidelines and support available for Non-Annex 1 countries in the preparation of National Communications. Initial communications should include: 1) national circumstances (i.e. national economic data and development priorities), 2) inventory of GHG emissions, 3) general description of programs, policies, and measures, 4) projects proposed for financing, and 5) financial and technological needs and constraints. He reviewed the areas that are eligible for financial assistance from UNDP/UNEP and the steps for requesting assistance.

Ron Benioff provided an overview of the U.S. CSP's current activities, which include: 1) assistance to countries preparing Climate Change Action Plans; 2) support for technology assessments and development of technology initiatives; and 3) enhancing the exchange of information and expertise in support of the FCCC. U.S. CSP has already awarded support for national action plans to 18 countries, and may extend assistance to three or four more countries in 1997.

U.S. CSP is providing technical assistance through workshops, publications, and individual training on mitigation measures and preparation of national action plans. U.S. CSP's international workshops, synthesis report for COP3, electronic network, and visiting analyst program all aim to support the exchange of information and experience between countries.

Richard Hosier made a presentation on GEF's Climate Change Operational Strategy and the role of the UNDP. He stated that UNDP/GEF priorities included: 1) enabling activities to help countries prepare National Communications, 2) removing barriers to energy efficiency, energy conservation, and the adoption of renewable energy; and 3) reducing the long term costs of low GHG-emitting energy technologies.

Alois Schneider of Germany's Federal Ministry for Economic Cooperation and Development described the role of climate protection in Germany's bilateral development cooperation with China. He outlined the three priority areas for the Germany-China collaboration: 1 poverty alleviation, environmental and resource protection, and education and training—stating that climate protection figured prominently in this framework. For all sectors with climate protection potential, he cited personnel training and increased institutional capacity as key factors for success.

For example, a network of advisory services has been established between GTZ and several power plants in China to improve energy efficiency. Joint projects are being implemented with the goal of rehabilitating coal power plants and improving the quality of the fuel used. In the non-energy sector, Schneider mentioned afforestation efforts underway in Northern China and the Yangtze region, which are receiving financial assistance from Germany, as well as assistance for forest management projects in China.

Holger Liptow presented an overview of the German support program to implement the FCCC. He explained that initially the program concentrated on inventory studies and country studies on mitigation options. Once established, the scope of the program moved toward identifying approaches with a more sectoral or regional emphasis. There also has been linkages between other, ongoing and completed, technical support projects in the energy sector. He provided examples of projects in Thailand, Zimbabwe, and India. The German program also funded the studies on Indonesia, the Philippines, Tanzania, and Thailand presented at the workshop.

Rene van Berkel presented an approach to conducting national technology needs assessments for the preparation and implementation of climate change action plans, recognizing the opportunities and constraints of such assessments as a planning tool for capacity building and the transfer of environmentally sound technologies. Assistance to developing countries in this regard is most likely to be successful if it is tailored to a country's development needs and is endorsed by key stakeholders in a country. Therefore, van Berkel proposed a participatory planning process, which would define a national climate change action plan, and contribute to the creation of support base for its acceptance and implementation among stakeholders in the developing country.

Activities Implemented Jointly

Overviews of the US and Netherlands initiatives on joint implementation were presented by Robert Dixon (for USIJI) and Art Kant (for the Netherlands AIJ Program). Dixon outlined the USIJI project criteria and noted that 22 proposals had been accepted to date, involving a wide range of technologies and sectors. Preliminary estimates show that net emission reductions as a result of these projects is expected to be over 40 million metric tons of carbon equivalent.

USIJI provides limited support to project developers to create credible proposals, and also provides assistance in developing institutional and human capacity, via outreach efforts, training and technical assistance activities, and other support activities.

Art Kant presented an overview of the Dutch AIJ program, called the Joint Implementation Facility (JIF), including its institutional organization, its relevance to the Netherlands' environmental and development policies, and its main characteristics. JIF's focus is on industry, energy and transport. Projects should fit the Dutch development objectives of poverty alleviation and environmental sustainability. They should be demand driven and in line with national development objectives of host countries.

The Dutch program is still in an early stage. Its priorities for the future are to promote JIF to the broader Dutch community, design specific project approval procedures; promote the Dutch environmental technology industry to potential foreign partners, and screen and respond to the 30 -35 proposals submitted to date.

Lastly, Ingo Puhl of the IEA defined and discussed the importance of the AIJ additionality criteria. In one sense it refers to the idea that financing of AIJ should be additional to the financial obligations of developed country parties. It also refers to the requirement that AIJ bring about climate change benefits that are additional to what would have occurred in the absence of such activities. Puhl argued that a clear definition of additionality was necessary to 1) avoid softening of commitments of Annex I countries (by defining more clearly what can be credited and ensuring that benefits are not overstated), and 2) limit free riding and double dividends for commercial investors and investors with objectives different from climate change abatement. The question that needs to be resolved is how to define additionality so that it achieves the goals stated above and is also practicable and cheap enough to make AIJ attractive to potential investors.